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Contents

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ABSTRACTORS

AGRICULTURE

A. W. Stableforth, D.Sc., M.R.C.V.S., D.V.S.M. . . *Animal Health**
H. P. Donald, D.Sc., A.R.I.C. . . . . *Animal Breeding*
S. M. Boden, B.Sc., A.R.I.C. . . . . *Animal Nutrition**
W. Morley Davies, M.A., B.Sc., F.R.I.C. . . . . *Soils**
T. E. Williams, B.Sc. . . . . *Herbage**
D. H. Robinson, B.Sc., Ph.D., N.D.A. . . . . *Crop Husbandry*
C. Culpin, M.A. . . . . *Machinery**

HORTICULTURE

H. B. S. Montgomery, B.A., Ph.D., D.I.C. . . . . *Fruit**
E. Skillman, B.Sc., N.D.H. . . . . *Glasshouse Crops**
Professor R. H. Stoughton, D.Sc., A.R.C.S. . *Flowers and Soilless Culture**
William Plant, B.Sc.(Hort.), Ph.D., N.D.H. *Nutrition of Horticultural Crops**
E. J. Winter, M.Sc. . . . . *Vegetable Crops**

GENETICS

J. L. Fyfe, M.Sc. . . . . *Crops and Plant Breeding**

DAIRYING

A. T. R. Mattick, B.Sc., Ph.D. . . . . *Dairy Bacteriology**
A. S. Foot, M.Sc. . . . . *Dairy Husbandry*

POULTRY

R. Coles, M.Sc.(Econ.), B.A., Ph.D., M.Sc. . . . *Poultry Husbandry**

PLANT PATHOLOGY

L. N. Staniland, A.R.C.S. . . . . *Entomology*
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The Veterinary Investigation Service

D. W. MENZIES

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TWO YEARS AGO, in this REVIEW*, a brief outline was given of the development of the Veterinary Investigation Service, the areas served by the different laboratories, and the type of work undertaken. Examples were given of the investigations which were in progress and which were discussed at the annual conference held at Weybridge. This article deals with some of the conditions included in the reports of the Veterinary Investigation Officers and discussed at the 1955 conference.

Cattle

MASTITIS

The work in connection with the eradication of *streptococcus agalactiae* has been continued at many centres, and herds which have been cleared of this infection have remained clear for up to five years. Mastitis in milking cows is often caused by other organisms, notably staphylococci. In some of the " problem " herds, that is herds with a high incidence of clinical mastitis, milk samples may yield a variety of streptococci and staphylococci, while a number are sterile on examination. In such herds the milking routine is always checked to see whether the teat cups are left on after the flow of milk has ceased, thus injuring the base of the teat. The soundness of the teat cup liners and the vacuum at which the milking machine operates are also examined. It has been found that where any necessary adjustments were made, the incidence of clinical mastitis was greatly reduced.

" SUMMER " MASTITIS

Summer mastitis is the name given to a severe form of mastitis which affects the dry cow and sometimes the maiden heifer. The disease is much more common during July, August and September, but cases may occur throughout the year.

In the summer of 1954, an unusually large number of cases of the disease appeared, particularly in southern England. Enquiries among the veterinary surgeons in practice in Somerset yielded

*The Veterinary Investigation Service. D. W. MENZIES. *N.A.A.S. Quarterly Review No.* 20, pp. 329-36.

information that permitted an estimate of the number of cases in the county. It was calculated that at least 4,500 cases occurred in Somerset in the six weeks August 1 to September 11. The damage to the udders of affected cows was severe, and just under 3 per cent of the animals were salvaged for meat, as they were useless for milk production. The mortality rate among the animals was approximately $1\frac{1}{2}$ per cent.

Formerly all cases of summer mastitis were thought to be due to infection with the organism *Corynebacterium pyogenes*, but in recent years, other germs, notably two types of streptococci, have been found in affected quarters. Sometimes these organisms appear in combinations, and these vary in different parts of the country. It is noteworthy that a streptococcal infection of the udder in the dry cow may present a clinical picture which is indistinguishable from *C. pyogenes* infection—the discharge is thick and evil-smelling and the cow herself is very ill.

As *C. pyogenes* is a distant relative of the human diphtheria germ, both a toxoid and a serum were soon available. It was found that it was often not possible to produce a satisfactory immunity with the toxoid, and whether the serum was of value in the treatment of cases of the disease was the subject of much argument. It has been said that the serum saved the cow but rarely saved the quarter. The fact that *C. pyogenes* is frequently found in abscesses in all classes of livestock, very often secondary to another germ, led to the theory that in summer mastitis the infection with *C. pyogenes* in the udder probably followed another infection, such as a streptococcus.

About five years ago, throughout England and Northern Ireland, and over three consecutive seasons, fortnightly udder infusions, which contained a special preparation of penicillin that would persist for fourteen days, were carried out on cows as soon as they were dried off. The incidence of the disease was remarkably low in England during the years that the trials were running, but there was evidence that the injections of penicillin, via the teat canal, were of value in the prevention of the disease. In Northern Ireland more definite evidence of its value resulted.

Further trials were arranged in 1954, but the disease was on the wane before the first infusions could be given. However, only two cases of summer mastitis occurred in a group of 389 treated cows, whereas with a similar number of untreated cows, eleven cases were recorded.

Some work was done at Weybridge on the possibility that summer mastitis is fly-borne. A small black fly, *Hydrotaea irritans*, was particularly common in the summer of 1954, and examination of many of the flies showed them to harbour *C. pyogenes*. Much work remains to be done on the problem, and further investigations are being carried out this summer.

ABORTION IN CATTLE

A great measure of success in the control of Brucella abortion has been achieved by the widespread use of Strain 19 vaccine. Unfortunately, some farmers have failed to continue vaccinating each batch of animals, with the result that abortion due to Brucella infection has lately shown some increase. Continued vaccination is, of course, the only answer to the Brucella threat, but it is cold comfort to the farmer with a batch of heavily pregnant animals in which one or two have just aborted.

Vibrio foetus may also cause abortion in cattle, but this infection is more often associated with infertility. Many more herds have been found to be infected, proof being obtained either by the isolation of the organism from an aborted foetus, or by the mucus agglutination test carried out at Weybridge. Research into the treatment of vibriosis with antibiotics is in progress at Weybridge and the results obtained will soon be published.

Other pathogenic organisms, and even moulds, have been isolated from aborted foetuses, but there is a proportion of cases that are bacteriologically sterile. More comprehensive examinations are now being made in a search for other, more fragile, organisms, although it is well known that some abortions are the result of physiological derangement and are not due to a specific infection.

HYPOCUPROSIS

The work on copper deficiency has been continued and extended. The experiments in East Anglia confirmed the value of (1) intravenous administration of copper salts and (2) the feeding of cake containing copper salts to cattle showing low blood copper levels.

Another experiment was carried out in 1954 to assess the value of dressing pastures with copper sulphate as a preventative of copper deficiency. Sufficient pasture to maintain 50 store cattle during the summer grazing period was sprayed during mid-March with copper sulphate, at the rate of 5 lb. per acre. A similar acreage of untreated pasture was left for 50 control cattle. The cattle were turned on to these pastures on April 1. They were weighed at monthly intervals from April to October inclusive, and blood samples were taken from eight beasts in each group for copper analysis. The results showed that, although the blood copper levels of the group of cattle on the untreated pasture fell to an average of 0.03 mg. per 100 ml. some time between June and July, they continued to increase steadily in weight. Over the whole period of the experiment these cattle actually gained an average of 30 lb. more per head than the cattle on the treated pastures. There is no obvious explanation for this, unless it is that the appearance of clinical symptoms of deficiency depends not only on a depleted copper reserve, but also upon some other factor, the nature of which is, as yet, unknown.

Studies on hypocuprosis in the young bovine are also in progress on the Shropshire-Wales border. Preliminary results have confirmed the benefits of copper salts administered intravenously.

HYPOMAGNESAEMIA

The sudden death of valuable cattle is always disconcerting and, unfortunately, such cases, associated with low blood magnesium levels, are relatively common. It is recognized that the condition may occur even though the diet contains adequate amounts of this mineral. It is also well known that the addition of magnesium salts to the diet will maintain the blood magnesium levels and prevent the onset of clinical symptoms. Top-dressing of pastures with dolomite is recommended in Scotland, and Weybridge reported good results from top-dressing pastures at Reading. It is hoped to obtain much more information on the value of pasture-dressing, if possible on a controlled basis ; i.e., by dividing the pasturage and animals into two, and top-dressing one half of the pasture with magnesium salts. Only by a number of trials of this kind on different soil types will it be possible to make recommendations on the control of this hypomagnesaemia condition in the bovine.

Other conditions among cattle which are receiving attention include husk, parasitic gastro-enteritis and coccidiosis.

Sheep

NEMATODIRUS INFESTATIONS

Parasitic gastro-enteritis still remains a very important cause of economic loss. The introduction of phenothiazine led to a much better control of the condition, although outbreaks still occur. In the last few years a species of parasite, Nematodirus, which lives in the small intestine of the host, has caused quite serious losses, particularly in the border counties. *Nematodirus filicollis* has been known for many years, but in these outbreaks a new species, *Nematodirus battus*, has been identified. Also, in many outbreaks the infestations consisted almost entirely of nematodirus species, whereas, in the past, a post-mortem examination of a sheep which has died of parasitic gastro-enteritis has generally yielded a multitude of species of nematode worms in the fourth stomach and also in the intestines. This disease affects lambs in late May, June and into July. Losses have been severe and have affected many farms in certain districts of the northern counties. The parasite nematodirus is quite unaffected by phenothiazine in normal therapeutic doses, and trials with other drugs, such as hexachlorethane, have failed to provide a reliable anthelmintic. It has been noted that nematodiriasis tends to clear up spontaneously in an affected flock during the month of July. The epidemiology of the disease is being studied intensively in the hope of devising a satisfactory means of control.

LIVER ROT

The liver fluke is always with us, and 1954 will go down in history as a bad year for fluke, just as it was a bad year for weather—and of course, the two go together. There were many outbreaks of acute fluke in the autumn, that is, wasting of the sheep owing to severe liver damage caused by large numbers of small, immature flukes migrating through the liver. Unfortunately, the normal therapeutic doses of carbon tetrachloride and hexachlorethane have no effect on the immature flukes, and recourse must be had to very large doses of these drugs in the hope that the fluke infestation in the liver will be reduced sufficiently to allow the animal to recover.

In several areas Black disease also caused losses. This condition is due to infection of the liver, already damaged by the migrating, immature flukes, by the organism *Cl. oedematiens*. Some measure of control can be obtained by controlling the fluke, and there is now an effective vaccine which immunizes the sheep against *Cl. oedematiens*.

CONTAGIOUS PUSTULAR DERMATITIS (" ORF ")

Some severe outbreaks of this virus disease occurred during the year. In at least one case the owner was convinced that his sheep had contracted myxomatosis from the rabbits which were dying in large numbers on the farm. Naturally, the owner also thought that the mortality rate in the sheep would be extremely high. Transmission tests with material confirmed that the condition was, in fact, contagious pustular dermatitis. It was quite a virulent strain of virus, which passed readily to the sheep, but not to the rabbit. A vaccine is available for the control of " orf " and is widely used in districts where the disease occurs.

PASTEURELLA SEPTICAEMIA

Organisms grouped as " pasteurella types " are frequently isolated from the pneumonic lungs of sheep, but tests with the strains isolated on laboratory animals generally show them to be non-pathogenic. Deaths, either sudden or within twelve hours, have occurred in lambs, and bacteriological examinations have shown that pasteurella organisms have invaded all the body tissues. Tests with the organism have shown that it is very pathogenic to lambs, given either subcutaneously or per os. Further investigations on the problem are in progress.

Other problems affecting sheep, which are being studied, include vaccination against enzootic abortion and enterotoxaemia.

Pigs

It is generally recognized that there is a considerable wastage of piglets between birth and weaning. Surveys carried out in past years showed that about 20 per cent of the piglets die during this

period. The increase in pig population in the past few years has resulted in a much greater number of pig carcasses being sent to Veterinary Investigation Centres for examination; in some areas the number has quadrupled. It is quite clear, as a result of these examinations and subsequent field investigations, that disease plays a far more important part in piglet mortality than has been hitherto recognized.

CL. WELCHII INFECTION

An investigation was made into the cause of heavy piglet mortality on two Hertfordshire farms. On one of these farms, 79 litters were born between December 1952 and February 1954 inclusive and amongst these, heavy losses occurred in 20 litters. Of the 197 piglets born alive in the 20 litters, 155 died before they were 72 hours old. On the second farm, losses occurred in 10 out of 70 litters born between January 1953 and March 1954, and 47 piglets died out of the 112 born alive.

The affected piglets showed a little red scour just before death. The main finding at post-mortem examination was acute haemorrhagic enteritis, mainly affecting the jejunum. The investigation showed that the deaths were caused by enterotoxaemia, due to invasion of the wall by *Cl. welchii* type C and the production by this organism of beta toxin. The sows were shown to be excreting the organism in faeces. On both farms losses have ceased following the routine injection of all piglets at birth with lamb dysentery serum, which contains beta anti-toxin.

Enterotoxaemia has also been encountered in 7—10-day old piglets on a Norfolk farm, so that it would seem that the condition may be a fairly common cause of piglet mortality.

STREPTOCOCCAL INFECTION

Streptococcal meningitis and arthritis, occurring in piglets between two and six weeks of age, was investigated in East Anglia and the results of the work have been published. The former condition is characterized by partial or complete inability to maintain balance, and the latter by a suppurative condition of the joints. Infection may be confined to a single litter in a piggery, although in some herds the condition may appear on a succession of litters over many months.

NUTRITIONAL DERMATITIS IN STORE PIGS

This is a condition superficially resembling sarcoptic mange that typically occurs in young store pigs receiving dry meal *ad lib.* There is a widespread belief among pig-keepers that it can be cured or prevented by the use of " wet " feeding.

The condition has been seen in many parts of the country and appears to be widespread among pigs kept on the hopper system. Some mild cases may go unnoticed by the owner, while other pigs,

with obvious skin lesions, may still appear to thrive normally. In many cases the condition causes a severe check in growth, delays the attainment of bacon weight by a period of up to two or three months and causes considerable economic loss.

The onset of the condition is usually observed in pigs 10-12 weeks old, although closer inspection will often disclose cases in unweaned piglets of 6 weeks and over. It begins as a papular eruption affecting the hams, inner aspects of the thighs and the belly. Later the lesions tend to become localized over and below the hocks and knees, where the skin is thickened and may show deep cracking and a heavy scab formation. The growth rate is often checked, the hair becomes long and coarse, and the skin may show a generalized hyperaemia. Skin scrapings often show the presence of a few sarcoptic mange-mites, which are less numerous than in classical cases of sarcoptic mange. Little or no response is shown to the use of mange dressings such as "Lorexane". Some outbreaks are complicated by the presence of clinical cases of sarcoptic mange. Nearly all the cases investigated have shown two common factors, namely, the use of the unrestricted feeding of dry meal and the presence of sarcoptic mange-mites. It is therefore thought that the condition may have a dual causation, involving both a nutritional factor and the presence of mange-mites.

A field trial has been carried out in an effort to substantiate the widespread belief that the condition responds to a change to wet feeding. This trial utilized 34 ten-week-old pigs, which had developed dermatitis while running out on lucerne with hopper feeding. The pigs were divided into two comparable groups, one of which was kept on the hoppers while the other was changed to a form of wet feeding.

The skins of the wet-fed pigs showed a rapid improvement, and were practically normal at the end of eight weeks, whereas the dry-fed pigs showed little, if any, improvement. During this eight-week period, the dry-fed pigs gained an average of 29 lb. at a food conversion ratio of 4.6 to 1, while the wet-fed group gained 46 lb. at a conversion ratio of 3.4 to 1.

Other diseases encountered in pigs in this country in the last two years included Aujesky's disease and inclusion cell rhinitis. The investigations into haemolytic disease of piglets have been continued.

Poultry

FOWL TYPHOID

Many centres participated in controlled trials using furazolidone in the food where outbreaks of fowl typhoid occurred. The losses were greatly reduced, and in many flocks ceased entirely during the six days in which the drug was being administered, but losses tended to recur when the treatment ceased.

Mortality rates in six flocks included in the trial were as follows :

	Treated	Controls
	per cent	*per cent*
Flock 1 . . .	4	32
„ 2 . . .	25	50
„ 3 . . .	12	24
„ 4 . . .	3	20
„ 5 . . .	7	14
„ 6 . . .	14	35

Of the surviving birds, about the same number in the treated and control groups reacted to the blood agglutination test against *salmonella gallinarum.*

In Northern Ireland, strict hygienic precautions were instituted when the drug was administered and all the birds in 40 flocks were treated. Results were good and losses very low.

PULLET DISEASE

This puzzling disorder appears to be on the increase in most areas. It is, of course, most common in pullets in autumn or early winter, but it can also affect older hens and even cockerels. Nothing is known about the cause of the condition, which varies greatly in its severity. Promising results have been obtained with terramycin, and further trials with this drug will be made when the opportunity occurs.

ROUND HEART DISEASE AND BLACKHEAD

The incidence of these diseases appears to have increased. The most significant lesion in the former is enlargement of the heart, degeneration of the cardiac muscle, and a rounded appearance of the apex of the heart. Death is sudden, and though the mortality rate is generally low, it may be as great as 50-60 per cent. The cause of the condition has not been established. Blackhead is, of course, more common in turkeys, but it appears to be encountered with increasing frequency in the growing chicken. Losses in any particular flock are generally low.

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Soluble Salts in the Soil

C. S. HARPER

National Agricultural Advisory Service, South-Western Province

CONSIDERABLE INTEREST has been aroused during the past five years in the accumulation of soluble salts in various soils, and in the effect that such accumulation has on the soil and on the plants growing in it. Broadly speaking, there are two classes of soils in this country which suffer from this high level of soluble-salt contamination: the older glasshouse soils, and areas which have recently been flooded by salt or brackish water. Little original work has been done on either of these classes of contaminated soils, most workers in this field confining themselves to semi-arid soils which, though similar in many respects, have markedly different characteristics. This article attempts to summarize the position to date and includes, as a matter of interest, some reference to the work in semi-arid irrigation areas.

Origin of Soluble Salts

Wherever evaporation and transpiration are greater than rainfall, soluble salts accumulate in the surface layers of the soil, due to the absence of a flow from the drains to carry away the salts produced by decomposition of soil minerals and added in the form of lime, fertilizers, etc. Under natural conditions, this happens in low-lying, arid or semi-arid areas where the water table is near the surface; areas which, under more humid conditions, would become marshes or swamps. Soils of this type are known as saline soils or solonchaks. In English conditions it is of course impossible to find a natural solonchak, but the necessary conditions are often artificially induced in the greenhouse. Evaporation and transpiration are high, heavy applications of soluble fertilizer salts are made, and watering is kept to the minimum for economic reasons—sufficient being given to keep the plants growing satisfactorily, but too little to cause the drains to flow. The water which is available often contains dissolved salts sufficient to increase, rather than decrease, the load of soluble material already carried by the soil, as is the case if the water is hard, or if the well from which it is drawn penetrates into strata carrying brackish water from an estuary.

Out-of-doors, certain exceptional conditions can give rise to high temporary concentrations of soluble salts in the soil. This happens when exceedingly heavy amounts of salts are added to a soil, and persists until natural rainfall has had time to wash them away. Examples of such temporary troubles occur after flooding with sea water, spreading of salt-rich soil from open-cast coal sites, ditch clearing, etc. The natural solonchaks and the sea-flooded soils contain a preponderance of sodium, magnesium, carbonate and chloride, whereas the artificial saline soils of the greenhouse contain less sodium

and more calcium and sulphate, the latter being left behind after the crop has taken its nutrients from such fertilizers as sulphate of ammonia, sulphate of potash, superphosphate, etc.

Effects on Soil

High levels of soluble salts in the soil have detrimental effects on it physically, chemically and micro-biologically.

Physically, the structure is impaired. The effect is far worse under conditions where sodium predominates but it cannot be ignored in other cases [16]. While the actual salts are still present there is usually a good "false tilth" due to the flocculating effect of the electrolytes, but when the salts are leached out a rapid deterioration of structure can occur. Sodium reduces and calcium enhances the liquid and plastic limits and the linear shrinkage of the soil [26]. Cultivation of the sodium soil in the dry state will cause bad physical conditions, after subsequent irrigation, by decreasing the water-holding capacity and aeration, and increasing the hardness of the soil crust on drying, especially if the exchangeable sodium is above 15 per cent of the BEC [7]. High salt concentrations also alter the water regime of the soil, changing the form of the pF/moisture-content curves [3] and considerably lowering the rate of penetration of water when the exchangeable sodium is greater than about 8.5 per cent of the BEC [12], and the actual salts have been removed. While the salts are present permeability is often enhanced [22].

Chemical changes occur mainly on the base exchange complex; the high concentrations of cations causing almost complete saturation of the clay with the predominating elements. The soil solution increases in alkalinity [3] after an initial fall in pH, which is greater if the contaminating salt is calcium sulphate than if it is sodium chloride [4]. In the case of seawater flooding the magnesium, potassium, and sodium ions on the complex are increased at the expense of calcium and hydrogen [50]. What happens to the phosphate and humus contents is the subject of some controversy. In natural saline soils it is stated that there is no alteration in these values [4], but Shawarbi [46] makes it clear that the phosphate is immobilized and that if the salts have originated primarily from fertilizer residues, as in glasshouse practice, high phosphates will be expected.

Changes are brought about in the micro-fauna and flora of the soil which affect the humus content. Quite high concentrations of salts stimulate the bacteria at first but a periodicity is observed [4] until finally a general deterioration of activity occurs, especially among the nitrite- and nitrate-producing bacteria, the effect on ammonifying and nitrogen-fixing bacteria being much less pronounced [20]. The micro-organisms rapidly revive after the removal of salts [25].

Effects on Plants

There are two classes of damage to plants; one due primarily to the physical changes in the soil and independent of the actual salts present, and the other due to the specific action of individual ions on the plant.

The dominant physical effect is that of the changed water regime—higher osmotic pressure, reduced permeability and lack of aeration. The first reaction to these changed conditions is shortage of water. The higher osmotic pressure makes the water in the soil less readily available [51] and raises the wilting point [24], although the actual symptom of wilting is often masked by the leathery turgidity of the leaves of plants growing in saline soils [45]. After the plant has endured these conditions for some time, the secondary effects of the physical deterioration of the soil make themselves felt. The poor aeration and low permeability, together with the actual corrosive action of the salts cause root damage, and saprophytic organisms quickly attack, causing a brown, unhealthy corkiness of the roots [34].

Owing to the presence of large amounts of available soluble material, the plant takes up greater quantities of ions than it does in more normal soils. This means that the ash content of such plants is unusually high for the species, and that species which normally inhabit saline soils have higher ash contents than those which do not. It has been recorded [17] that the ash content of a group of plants increased from 3.7 per cent, when they were growing in a soil containing 0.1 per cent salts, to 13.8 per cent, when they were growing in a soil containing 2.2 per cent salts. The same author points out that the ratio of the various ions in the plant differs from that in the soil. The general toxicity of salts, irrespective of the particular ions present, causes the plants to be dwarfed and stunted, the leaves to take on a dull, blue-green coloration and, in extreme cases, to become coated with a waxy deposit [45]. Often the leaves become distorted and twisted.

The specific toxic effects of particular ions fall into two classes; those operative at low and those at high concentrations [45]. The former need not concern us here. Other ions when present in high concentrations have toxic effects which increase the harm caused merely by their concentration. Thus, crops like potatoes, beans, and tree fruits (e.g., vines, peaches, etc., in glasshouses) are damaged by chlorides at concentrations at which sulphates do not harm them [41 and 45], whilst others, like flax and the grasses, are more tolerant of chlorides than sulphates. Again, at equal high osmotic pressures, magnesium ions are more toxic than calcium, and calcium more than sodium, though high sodium levels can cause calcium deficiency [45].

Measurement of Salinity

The concentration of salts can be determined by simple chemical means in the water extract of soils, but this is a laborious process and quicker methods have been devised. These depend on either the

measurement of the osmotic pressure of the soil solution or on its electrical conductivity. This latter method is extremely easy and rapid because the electrical conductivity of an aqueous solution depends on the concentration of salts dissolved in it. Thus, two electrodes of known dimensions are immersed in a suspension of 1 part of soil to $2\frac{1}{2}$ parts of distilled water and the resistance between them measured by any of the usual methods. The determination has either to be carried out at some standard temperature (usually 20° C.) or an allowance made for the change in resistance with temperature.

Owing to the effect of polarization, a high-frequency alternating current has to be used in this determination. The various methods have been compared [11] and the electrical method found to be most accurate at small concentrations. Obviously, the relationship between the various means of expressing salinity depends to some extent on soil type and the actual salts present, but for practical purposes it is possible to give *approximate* equations connecting them [53].

The following terms have been used :

C = *Specific conductivity* (mhos per centimetre cube). This is the reciprocal of the resistance, measured in ohms, between the opposite faces of a centimetre cube of the solution.

CF = *Conductivity factor* (millimhos per square centimetre per decimetre). This is the term used in some Provinces of the N.A.A.S.

O = *Osmotic pressure* (atmospheres). The suction pressure required to extract water from the moist soil.

P = *Salt concentration* (per cent). The number of grams of soluble salt extractable from 100 g. of soil by water leaching.

*p*C = *Concentration potential* (no units). The negative logarithm of the specific conductivity. This term has been used by analogy with *p*H, *p*K, *p*S, etc., to convert the inconveniently small values obtained for C to a more handy size. It is the term used in most Provinces of the N.A.A.S.

*p*F = *Capilliary potential* (no units). The negative logarithm of the soil moisture tension in cms. of water. It is related to the osmotic pressure and depends on moisture content as well as salt concentration.

*p*L = "*Lectic*" *potential* (no units). A term introduced to express the relationship between salt concentration and base saturation.

*p*N = *The common co-logarithm of the normality of the soil solution* as usually defined.

*p*S = *The common co-logarithm of the salt concentration* expressed as grams weight per millilitre.

These values are *approximately* related as follows in the normal range of salt concentration in average soils, where M is the percentage of water added to the dry soil to give the suspension on which the conductivity is determined.

$$\begin{aligned} CF &= 10{,}000C \\ O &= 550C \\ P &= \frac{100\ C.M.}{165} \\ pC &= -\log C \\ pF &= 5.74+\log C \\ pL &= 2\,pH+\log C \\ pN &= 0.83-\log M-\log C \\ pS &= 2-\log M-\log C \end{aligned}$$

Using these equations it is possible to show the *approximate* relationship existing between the various values in tabular form. Table 1 has been calculated on the assumption that a soil-water ratio of 1 : $2\frac{1}{2}$ is used for the determination of the electric conductivity; other dilutions will affect the last two columns of equivalents.

Table 1

Classification	*p*C	CF	Specific Conductivity	Salts in Dry Soil	c.p.a. Salts
				per cent	
VL	3.30–∞	0–5	0.0000–0.0005	0.00–0.07	0–15
L	3.15–3.29	6–7	0.0006–0.0007	0.08–0.10	16–21
ML	3.00–3.14	8–10	0.0008–0.0010	0.11–0.15	22–30
M	2.82–2.99	11–15	0.0011–0.0015	0.16–0.22	31–45
MH	2.70–2.81	16–20	0.0016–0.0020	0.23–0.30	46–60
H	2.52–2.69	21–30	0.0021–0.0030	0.31–0.45	61–09
VH	0.00–2.51	31–∞	0.0031–∞	0.46–∞	91–∞

The value of *p*L has been used [38] to calculate the lime requirement of soils.

Salt Tolerance of Plants

Very little is known on this subject. It is bound up with many factors: the nature of the salts [41], the water supply, the temperature [33 and 45], the species [5], the age of the plant [15, 37 and 45], fertility of the soil [1, 48, 52 and 54], and *p*H [52]. Differences in tolerance for different stages of growth are very important; thus rye has a better germination capacity under saline conditions than barley, whereas the latter once established makes the better growth [37], particularly when the seed rates are raised. Lucerne is very sensitive to salts as a seedling, but when established is one of the most salt-tolerant of all normal crops [15]. Table 2 gives a list of plants compiled after considering the following references :

[2, 8, 9, 10, 13, 19, 23, 27, 35, 36, 37, 39, 40, 44, 49, 51 and 57],

and in it an attempt has been made to put plants in classes such that the limit of salt tolerance for any given species falls in the corresponding class of Table 1. Great caution should be exercised in any use of this table, because, as stated at the beginning of this paragraph, many complicating factors influence salt tolerance, and it is not unusual for a plant to be found thriving at much higher salt concentrations, or failing at lower ones, than those indicated. The plants with which we are most frequently concerned in this country are the glasshouse crops, particularly tomatoes and lettuce, but for interest and comparison, many common agricultural crops have been included.

Table 2

Limits of Salt Tolerance in Plants

Alsike . . . MH	Asparagus . . MH	Barley (*for grain*) MH
Antirrhinums . MH	Beet . . . VH	Bean . . . M
Barley (*for Hay*) . VH	Chrysanthemums MH	Clover (*red*) . ML
Carnations . . VH	Clover (*not red*) . MH	Lentils . . VL
Carrot . . . MH	Kale . . . H	Meadow fescue . MH
Cucumbers . . MH	Lucerne . . VH	Oats (*for grain*) . M
Flax . . . MH	Onion . . . MH	Peach . . . ML
Lettuce . . . ML	Pea . . . VL	Potato . . . ML
Maize . . . M	Plum . . . ML	Rye (*for grain*) . MH
Oats (*for Hay*) . VH	Ryegrass (*both*) . H	Smooth brome . MH
Pear . . . ML	Sainfoin . . VH	Tomato . . H
Red clover . . ML	Tall fescue . . VH	Wheat . . . M
Rape . . . VH	Vetch . . . ML	White clover . MH
Sunflower . . MH	Tree fruits . . ML	

It might be of interest to add here the tolerance of some of the native plants of the semi-desert.

Sudan grass	*p*C of 1.5
Seepweed	*p*C of 1.6
Salt grass	*p*C of 2.1

Reclamation of Saline Soils

The primary need is to remove the salts and this can be done in three ways. In natural solonchaks the high ash content [17], selective salt uptake [17], and high salt tolerance of such plants as lucerne [21], *Atriplex* [6 and 37], *Atropis* and *Beckmannia* [39] are made use of to remove the salt in their above-ground parts. This is, of course, not practicable under our conditions, but the channeling effect of the roots of tolerant plants should not be overlooked as a considerable aid to de-salinization of outdoor areas which may have become salty [1, 17, 32 and 54].

WASHING-OUT WITH WATER

A second, seemingly obvious, method of removal is to wash out the salt with copious amounts of water ; it may not be realized, however, just how much water is needed to do this. Growers rarely flood their glasshouses sufficiently, and frequently do not remove even the annual increment of salts added during the past season. It will be seen from Table 1 that a soil with a *p*C of 2.6, common enough in glasshouses where tomatoes have failed, will contain nearly four tons of salt per acre. This will theoretically require a minimum of 280,000 gal. to dissolve it, if, as in most glasshouses, it is mainly calcium sulphate. Thus a layer of water 1 *ft.* deep over the soil would be needed to entirely remove the salt if solution were complete. In actual practice such efficiency would never be attained and something like 4 ft. of water might be required, an application of 10 ft. having been found necessary under some conditions [14, 43 and 47]. Poor leaching can result from impeded drainage and it may well be that certain glasshouses cannot be flooded at all because the local topography or condition of the subsoil make it impossible to get the large quantities of water away.

Another difficulty about this method of reclamation arises from the salt content of the water supply. If the water is hard or brackish, it may be impossible to reduce the salt contamination in the soil unless some arrangement is made to change the supply, as for example, collection of the rainwater from the roofs of the houses themselves. The drying [18], heating or freezing [28, 29 and 30] of a soil before leaching assists salt removal by flocculation and removal of exchangeable ions. In this connection, though, it is as well to note that, since the potassium ions are easily removed and the phosphate ions more firmly driven into the clay mineral lattices by leaching [46], a serious lack of balance in soil fertility can result. Unless leaching is carried out very thoroughly there is a risk that the salts will merely be carried to the lower horizons, so that although the crop gets a good start in the salt-free surface soil, capillary action will bring the trouble up again as the season progresses. In one case in the writer's experience, a glasshouse with a *p*C of 2.5 was well flooded and the *p*C brought up to 3.3, but about six months later the *p*C in the upper layers had fallen again to about 2.6. The same capillary transfer of salts has been found to occur from a saline soil into pots standing on it.

REMOVAL OF CONTAMINATED SOIL

The third method of salt removal is to cart out the contaminated soil. This appears at first to be both drastic and costly, but it has been proved that mechanization, if at all possible, is the most economic answer in the long run. The writer knows of one large nursery where it was considered worth while to remove the ends of the houses, saw the heating pipes into sections, so that they might be slung from the roof, and then use a small bulldozer to push

out the old soil and push in the new. The grower was delighted with the results even in the first season. The whole of the soil to rooting depth need not be removed and it was found, as a result of pot experiments [56], that excellent results could be obtained if it were arranged that the glasshouse should finally contain a mixture of about one part of old, salty soil to three parts of the *poorest* soil available, omitting any base fertilizer.

STEAM STERILIZATION

Temporary alleviation of the trouble often results from steam sterilization. This is thought to be due to the interaction of the effects of salt and saprophytic organisms. For serious damage to occur on the roots two factors must be present: salt to cause initial weakening of the cells, and subsequently saprophytes to attack and destroy them. If we remove either factor damage will not be serious. Permanent reclamation removes the former factor and steam sterilization the latter. Heavy dressings of peat or F.Y.M. have been found to be beneficial [1 and 54] and probably act both by providing food for these same saprophytes as an alternative to the damaged roots, and by improving structure thus assisting aeration and leaching. In addition, humus has a well-known "buffering" action against all inhospitable soil conditions. Green manures, and organic nitrogen and phosphate, assist plants in their battle against salt. Organic sources of nitrogen are preferable in these circumstances because, although after decomposition they add their share of soluble salts to the already large amounts present, the effect is spread out over the life of the crop.

OUTDOOR TREATMENT

Much of the foregoing has been applicable to, and indeed only practicable on, indoor saline soils. Land which has been flooded by salt water comes into a rather different category. The exchange complex has been saturated with the foreign sodium ion and chemical amendments become valuable to return the soil to its normal exchange state. The most usually applied material is gypsum at up to four tons per acre [55]. This has been found to be more effective than calcium nitrate which only has slight effect, calcium chloride which causes plant injury, and calcium carbonate which is of low solubility except in acid soils [42], though in such soils it is of value when used in conjunction with leaching [52]. In sodium soils these chemicals hasten salt removal and improve the structure of the soil but some doubts have been expressed [14, 43 and 47] as to whether they are indispensable or even really economic.

Summary and Conclusions

Little is yet known about the subject of surplus soluble salts in soils under conditions prevailing in this country. The problem has

doubtless recently been brought into the foreground by the heavy rates of manuring common during the past twenty years or so, which have at last built up the salt concentration in intensively cropped glasshouses to dangerous levels, and also by the break through of the sea on our east coast. With help from Advisory Officers and relative experiments, a fund of knowledge about such things as soil deterioration, plant tolerances and methods of reclamation can be built up, enabling better advice to be given to growers who meet this trouble. One final word of warning seems advisable. On occasions in the past, when some scientific concept has been newly applied to agriculture, there has been a tendency to herald it as a solution to all kinds of agricultural problems. Salt contamination will be the explanation in only comparatively few cases of crop failure; it must not be taken as a facile solution of problems which should rightly be investigated to their ultimate cause.

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Recent Work on Plant Viruses

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IN THE FIRST NUMBER of this REVIEW* an account was given of some of the outstanding facts in the study of plant viruses and a selection of important plant virus diseases was briefly described. In the seven years which have elapsed since then it may be of interest to draw attention to some of the main developments during that period.

Latency

One of the most intriguing relationships between viruses and their hosts is that of latency, and it raises the question in some cases as to how far a latent virus is an invader which has achieved balance with its host, and how far it is a normal constituent of the cell. The phenomenon of latent viruses occurs in many different types of organisms besides plants, and is particularly common in insects.

There are various degrees of latency, and in plants a frequent occurrence is the development of a reaction, severe or fleeting, at the time of infection, after which the plants are apparently healthy. The various ringspot viruses fall into this category, and so does the economically important potato virus X, which once had the name in America of " the healthy potato virus ".

The truly latent virus, however, never causes a disease in the organism in which it is found. Perhaps the best-known example of this in the plant kingdom is the latent virus in *King Edward* potatoes, known as " Paracrinkle " and discovered by Salaman and Le Pelley in 1930 [31]. The virus is present in every plant of the *King Edward* variety, including the mutant *Red King*. It has never been found occurring naturally in any other potato variety or different plant, and has no known natural method of spread. It used to be thought that the virus was transmissible only by grafting, but Bawden, Kassanis & Nixon [2] have shown that it can be spread by mechanical methods of inoculation.

A more recently discovered virus which also falls into the category of true latency is one which occurs at particular seasons of the year in sugar beet. It seems to be present in sugar beet in any part of the British Isles, on the Continent, and even as far away as Southern California. It is not possible to tell from the appearance of the sugar beet if the virus is present ; inoculation must be made to an indicator plant, which in this case is the cowpea, *Vigna sinensis*, to test for its presence. If the virus is present in the sugar beet sap the inoculated

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leaves of the cowpea develop reddish necrotic lesions in about three days (Plate I). Once established in the cowpea, the virus is transmissible indefinitely to other cowpeas. Experiments to transmit this virus by means of various insects have failed, and it has not been possible to prove transmission either by the seed or through the soil. The question that arises, therefore, is how does this virus spread—if it does spread? There may, of course, be some factor that has been overlooked. It is possible, for instance, that the virus *is* seed-transmitted, but in quantities too small to be detected by the inoculation tests, and that it only shows up on the indicator plants when multiplication of the virus has taken place in the sugar beet.

Another interesting latent virus has been found recently in several potato varieties, including the variety *King Edward*. Kassanis [18] has shown that this virus comes from carnations and is transmitted by the aphid, *Myzus persicae*. The virus is transmissible to other plants in which it produces no symptoms, and in fact the sugar beet appears to be the only plant in which symptoms are caused.

An apparently latent virus has been isolated from anemones in the south-west of England. Inoculation from apparently healthy anemones to indicator plants reveals the presence of a virus giving local lesions. Plate I shows a leaf of *Chenopodium amaranticolor* with the characteristic lesions formed by the latent virus. The virus situation in the anemone-growing district is discussed in a later paragraph.

Relationships with Insects and other Arthropoda

For many years it was a controversial point as to whether a plant virus could multiply inside its insect vector. This has more than an academic interest since a plant virus which can multiply in an animal (and an insect is an animal—a fact sometimes overlooked by virologists), must also be to some extent an animal virus.

It has now been proved by the work of Kunkel [20], Black [4] and Maramorosch [23], that some plant viruses do multiply in their leafhopper vectors. Black found that the Clover Club Leaf virus was transmitted from viruliferous females of the leafhopper, *Agalliopsis novella*, to their progeny through the egg. He showed that the virus in a single female was capable of being maintained through twenty-one generations of progeny, during a period of five years, without fresh access to virus from plants. On the basis of the progeny counted it was calculated that the quantity of virus in the starting female would have undergone a dilution of 10^{-26} if it had not multiplied.

In a different approach to the problem, Maramorosch [23] worked with the virus of Aster Yellows which had been used much earlier by Kunkel [20]. Maramorosch employed the technique of inoculating the virus directly from leafhopper to leafhopper. He succeeded in transmitting the Aster Yellows virus through ten serial passages from insect to insect without loss of virus concentration. The dilution of the starting virus was calculated at the tenth passage to be 10^{-40}.

Black [5] has recently discussed the relationship between plant viruses and leafhoppers.

Although most of the plant viruses are transmitted by sucking insects belonging to the order *Hemiptera*, there are cases where the vectors are biting insects. An interesting example of this is the virus of Turnip Yellow Mosaic, which is spread in the field by one or more species of flea beetles. The power to transmit this virus seems to be closely bound up with the lack of salivary glands, which is in strong contrast to the spread of viruses by sucking insects where the saliva is the vehicle of transfer. The important factor seems to lie not so much in the lack of salivary glands as in the feeding habits which this lack engenders. Transmission of the Turnip Yellow Mosaic virus is dependent upon regurgitation from the fore gut during feeding, so that beetles and other biting insects which have this habit are vectors. In experiments the virus has been transmitted by any type of beetle which would feed upon the appropriate plants and, in addition, by earwigs and grasshoppers [25].

Until fairly recently the only case known of a plant virus with a non-insect vector was that of reversion of black currants, which is spread by the " big-bud " mite. Now, however, there are two more instances recorded. One is the virus of Wheat Streak Mosaic which has been shown by Slykhuis [33] to be transmitted by the mite *Aceria tulipae* ; the other is the virus of Fig Mosaic, a very common disease in California. Although this disease seemed to spread, search for the vector was not successful until Flock & Wallace [9] proved that it was also a mite. In view of these discoveries, mites may be found to be concerned with the spread of other plant viruses.

Cure of Plant Virus Diseases

The following is a brief discussion of the attempted destruction of the virus in the plant by chemical means, the inhibition of virus infection, the inhibition of virus development in the plant and the cure of virus-infected plants by heat.

CHEMICAL MEANS OF VIRUS DESTRUCTION

Very little work seems to have been done on the attempted destruction of the virus inside plant tissues by chemical means. Stoddard [35 and 36] has claimed that the X-virus of peach can be destroyed by soaking infected peach buds in solutions of quinhydrone, urea or sodium thiosulphate. Norris [29] has tested the effect of malachite green on parts of potato plants infected with potato virus X. Only one out of fifteen pieces of stem was virus-free, although, according to Norris, the virus content of all the stems was much less than that of the controls.

VARIOUS INHIBITORS

The number of substances which can inhibit the infection of plants by viruses is very large and some of the early work on plant viruses established this fact. One of the first of these inhibitors to be discovered was the juice of the pokeweed, *Phytolacca decandra*, and others are the sap of spinach, sugar beet and Swiss chard.

Another type of inhibitor is the tannin which is liberated from rosaceous plants, especially strawberries, during the inoculation process. Bawden & Kleczkowski [3] have shown that not only is enough tannin liberated during maceration to precipitate all the plant proteins, but the supernatant fluid still contains about 1 per cent tannin—enough to precipitate Tobacco Mosaic virus and prevent it from infecting *Nicotiana glutinosa*.

Apart from those occurring naturally in plant sap there are many other inhibitors of infection. Normal and immune sera, enzymes, growth products of bacteria and fungi, miscellaneous substances such as milk, the juices of caterpillars, and the blood of fishes—all these inhibit the virus infection of plants. For a long time there have been two opinions as to how the inhibitors act; one was that the action was directly on the virus itself, the other that the resistance of the host plant was affected. From available evidence it looks as if the second theory was the correct one and this has recently been discussed by Bawden [1].

It is possible that some of these inhibitors of virus infection might have a practical application if sprayed on to the crop. The most likely crop to try would be tomato under glass, where the Mosaic virus is spread from plant to plant during the handling of the crop. Spraying the seedlings with ribonuclease or milk, as suggested by Bawden, might greatly decrease the spread of the virus.

INHIBITION OF VIRUS DISEASE

The two main substances used to inhibit virus increase or development in the plant are 2-thiouracil and 8-azaguanine. Commoner & Mercer [6 and 7] demonstrated that thiouracil greatly retards the development of Tobacco Mosaic virus in leaf discs floated on water. They also showed that the effect of thiouracil could be counteracted by an excess of uracil. In 1954 Bawden & Kassanis showed that thiouracil also retarded the development in tobacco of potato viruses X and Y, Henbane Mosaic and a tobacco necrosis virus.

Matthews [7 and 8] studied the effect of 8-azaguanine on the development in tobacco of a number of different viruses. He found that spraying the leaves of tobacco, and *Nicotiana glutinosa* infected with the virus of Lucerne (Alfalfa) Mosaic, with this substance retarded the rate of multiplication of the virus and also the rate at which it moved from the inoculated leaves. The action of 8-azaguanine can be countered by adenine and guanine, but not by uracil, xanthine

Photo : *S. Frey*

Leaves of cowpea *Vigna Sinensis*, showing local lesions caused by the latent sugar beet virus.

Photo : *S. Frey*

Leaf of *chenopodium amaranticolor*, showing the local lesions caused by the latent sugar beet virus.

PLATE I.

Photo : S. Vernon-Smith

Tobacco Mosaic virus, shadowed with palladium-gold, × 28,000.

Photo : *S. Vernon-Smith*

Section through part of a cell in a cucumber leaf, infected with cucumber virus 4 : note the rod-shaped particles on the edge of the chloroplast, × 30,000.

PLATE III.

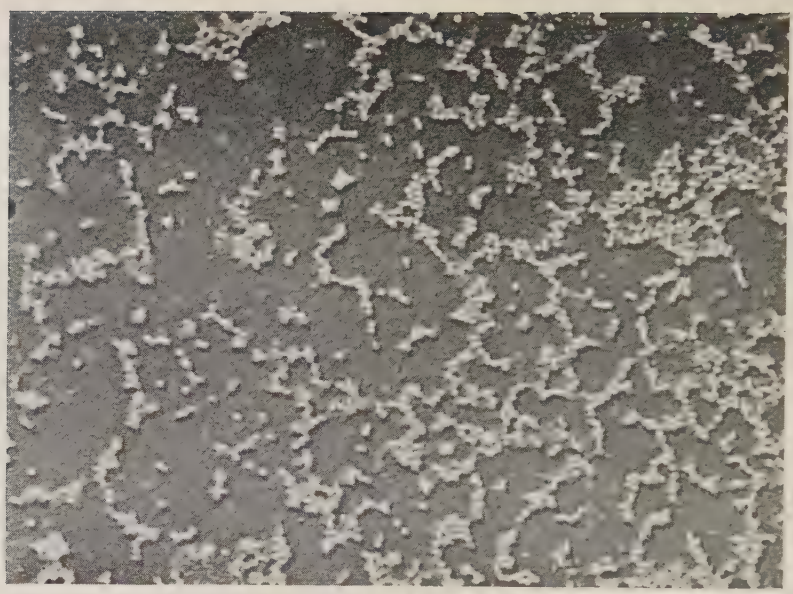

Photo : *S. Vernon-Smith*

Turnip yellow mosaic virus, shadowed with palladium-gold, × 28,000.

Photo : *S. Frey*

Virus-infected anemone plant with " broken " flower, probably due in this case to the virus of cucumber mosaic.

PLATE IV.

or thymine. Matthews showed the interesting fact that the 8-azaguanine is incorporated in the nucleic acid of the Tobacco Mosaic virus when it is sprayed daily on leaves of infected tobacco plants. He considered that this may account for the inhibition of virus multiplication.

HEAT TREATMENT

The heat inactivation of viruses in plants has been much studied in the U.S.A. by Kunkel [21] but not very much attention has been paid to the subject in this country. Kassanis [15] however, has shown that potato tubers can be cured of the Leaf Roll virus by storing them for not less than 25 days at a temperature of 37.5°C. in a humid atmosphere. Similar treatment up to 40 days did not free tubers from the potato viruses X and Y.

In a further paper, Kassanis [17] found that virus-free plants could be produced from parent plants systemically infected with the following five viruses: Tomato Bushy Stunt, Carnation Ringspot, Cucumber Mosaic, Tomato Aspermy and *Abutilon* Variegation. The leaves formed while the infected plants were kept at 36°C. were free from symptoms and test plants inoculated from these remained uninfected. When cuttings were taken from the infected plants at the end of the treatment most of them grew into healthy plants. The treated plants themselves usually developed symptoms after varying lengths of time at 20°C. It is an interesting fact that heat-therapy seems not to be correlated with the thermal-inactivation end point of the virus *in vitro*.

Another successful instance of heat-therapy is the cure of strawberry plants infected with Crinkle [30].

Electron Microscopy of Plant Viruses

When one considers how recently the first photograph of a virus on the electron microscope was taken, the progress made in the application of this instrument to the study of viruses is remarkable. It was in 1939 that Kausche *et al.* photographed the virus of Tobacco Mosaic and showed it to be a long thin rod (Plate II), a fact already foreshadowed by other physical methods. Then in 1941, Stanley & Anderson photographed a number of plant viruses, that of Tobacco Mosaic, Cucumber viruses 3 and 4 (Plate III), Tomato Bushy Stunt and tobacco necrosis viruses. They showed that the last two were spherical in shape, as is also the virus of Turnip Yellow Mosaic (see Plate IV).

If these early photographs are compared with similar pictures at the present time, it will be noticed at once that whereas the former appear rather faint and obscure, the latter stand out from the picture with a 3-dimensional effect. This is due to the technique of

metal shadowing which was developed by Williams & Wyckoff [37], who showed that this method could be used in the photography of virus particles. Briefly, the technique consists of vaporizing a thin metal wire of palladium-gold, uranium or chromium in a high vacuum, so that the virus particles are coated at an angle with a very thin film of metal. This film is opaque to the electron beam so that a shadow is cast by the particles. By this means, not only the size but the shape and general appearance of the particle stands out clearly.

It would be very exciting if it were possible to examine living virus-infected cells with the electron microscope, because information could then be obtained on the mode of development of viruses. Since this cannot be, the next best thing is to examine fixed tissue. This has been made possible by a new technique of cutting ultra-thin sections. The tissue is fixed, usually in buffered osmic acid, and embedded in plastic (polymerized butyl methacrylate), first used by Newman *et al.* in 1949 [28]. The sections are then cut on a specially designed microtome, which will produce sections thin enough (0.2μ) to allow the electron beam to penetrate. It is possible to remove the plastic from the sections by immersion in amyl acetate and then to shadow them with metal, as is usually done with virus particles. This gives very striking results. However, it is now the general opinion that it is better to leave in the plastic and omit the shadowing, owing to distortion and disarrangement of the cell contents consequent upon the treatment with amyl acetate. In order to get good photographs by this method, however, it is essential to have the sections really thin.

So far most of the very thin sections have been made of animal cells and not much work has yet been done on the plant viruses. Leyon [22] has made a study of Tobacco Mosaic viruses and other viruses in sections of tobacco leaves and he finds that the virus seems to be associated with the chloroplasts.

The new technique now enables sections to be cut of the virus particles themselves and, with the resolution obtainable with the newest electron microscope, the sub-microscopic structure of the virus particle itself becomes visible.

Development of Virus-Resistant Plants

A great deal of work has been done, and is still being done, on the breeding of plant varieties resistant or immune to virus infection. On the whole the results have been encouraging, although there is always the risk of a new strain of the virus appearing which is able to overcome the resistance of the plant. This has happened recently with the disease " Spinach Blight " in America, which is caused by Cucumber Mosaic virus. Some resistant plants of spinach were observed to be naturally infected with " blight " in the field and Fulton [10] found that the strain of virus from these plants tended to overcome the resistance under experimental conditions.

The production of tomato plants resistant to the Spotted Wilt virus is an important problem for several countries, notably Australia, New Zealand and South Africa.

Certain strains of the red currant tomato, *Lycopersicum pimpinellifolium* Mill., and of the Peruvian tomato *L. peruvianum* Mill., are highly resistant to the Spotted Wilt virus under field conditions. Several genes appear to be of importance in this resistance and Hutton & Peak [12] think it will not be easy to incorporate these whilst still retaining the necessary qualities for an edible tomato.

Resistance in potatoes to the three principal viruses, potato viruses X and Y, and the Leaf Roll virus, is something to be greatly desired. Hutton & Wark [15] have studied certain potato lines derived from the X-resistant potato seedling S41956 and they found that the virus entered the plants when inoculated and could be recovered up to five days later. After seven days, however, the virus had disappeared, showing that the apparent immunity was really due to some inactivating agent in the plant.

The whole subject of the inheritance of resistance to virus diseases in plants has recently been ably reviewed by Holmes [11].

Multiplication of Viruses

We know very little of the multiplication process in plant viruses, but we now have experimental evidence that the nucleic acid is closely concerned with multiplication. This evidence was obtained by a study of the Turnip Yellow Mosaic virus. When purified and centrifuged for about 2 hr. at 12,000 r.p.m., the solution separates sharply into two components. The " top " component, which is usually about 20 per cent of the whole, contains no nucleic acid and is not infectious. The " bottom " component, which is otherwise similar in every respect, does contain nucleic acid and is infectious [25]. In a study of the physical properties of the two kinds of particles Markham [24] concluded that those of the bottom component contained the nucleic acid in the centre, while those of the top component were hollow. X-ray studies on the two types of particles carried out in America by Schmidt, Karsberg & Beeman [32] have confirmed this conclusion. The interesting questions arise as to what is the relationship between the top and bottom components and what is the exact significance of the top component lacking nucleic acid? Some work recently carried out by Jeener [14] suggests that the non-infectious particles may be the precursors of the infective particles, in other words a " provirus ". He used labelled carbon dioxide, and at a certain stage in the development of the Yellow Mosaic disease he introduced the plant into the labelled carbon dioxide. The fact that the carbon dioxide went first into the top component suggests that the non-infectious particles are an earlier stage in the synthesis of the virus.

Important Plant Virus Diseases

The disease of turnips and brassicas known as Turnip Yellow Mosaic, which is transmitted in nature by flea beetles, is now becoming of some economic importance. In an extensive survey of broccoli fields throughout the Northern Province in 1952, plants showing symptoms of Turnip Yellow Mosaic were observed on almost every holding inspected in the coastal area, from Amble in Northumberland to the Tees. The varieties of broccoli affected were *St. George*, *Midsummer*, *Whitsuntide*, *May Blossom*, *Pearl*, *Lenton Monarch*, *Hardy Late*, *Gigantic* and unnamed local strains. Symptoms have also been observed on Brussels sprouts.

During late March and April, 1953, the disease spread rapidly. On the holding where it was first noted, 90 per cent of the *St. George* plants showed symptoms at cutting time. Plants infected the previous autumn were either killed or failed to produce a marketable curd [8].

The main symptom which distinguishes this disease from the aphid-transmitted Cauliflower Mosaic and Cabbage Black Ringspot disease is the bright yellow mottling and blotching of the leaves. Incidentally, this is a virus disease which might perhaps be controlled by direct attack on the insect vector, since there are now efficient insecticides for the control of the flea-beetle vector.

The virus, or viruses, of tobacco necrosis which started as being only of scientific interest, are now a considerable menace to the tulip-grower. The method of spread of the virus is unusual since it has no insect vector but is soil-borne, entering the plants by the roots. The tulip variety *Korneforos* seems to be the most sensitive and also shows the most extensive damage. Kassanis [16] suggests that infection may take longer to reach the leaves than the growing period of the plant. In consequence, infected plants may go unrecognized until the following year, but in the meanwhile have been a source of contamination. The virus is widespread in Holland, where it also attacks the French bean crop, and has been recorded in Germany and the United States.

The situation in the anemone-growing districts of the south-west of England is rather curious because of the so-called " parsley leaf " disease. The exact relationship of virus infection to the parsley leaf is rather obscure, but preliminary studies by Short and Smith have shown that there are three viruses associated with mottling and other symptoms in the anemone. These viruses are the latent virus previously mentioned, a tobacco necrosis virus which probably is symptomless, and a strain of Cucumber Mosaic.

The aphid-transmitted Cucumber Mosaic virus is a cause of loss in many parts of the world and in a great variety of crops. It causes a Mosaic disease of bananas, the " woodiness " disease of passion fruit, and in this country it has been found attacking the buddleia, privet bushes, teasels, celery, *Daphne mezereum*, and possibly rhubarb.

In addition it infects many garden plants such as delphiniums, lupins, zinnias and gladioli. It frequently causes a colour-break in the flowers and an example of this is seen in the anemone (Plate IV).

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Abstracts

Animal Breeding

Studies on Monozygous Cattle Twins

In the tenth of a series of papers on monozygotic cattle twins (*N.Z. J. of Sc. and Tech. A.*, 1953, **35,** 189-98), J. HANCOCK briefly outlines the recent literature on the subject, and discusses it in relation to the results presented in his nine previous papers. He deals with what he regards as the four most important aspects to date of such studies :

the frequency of monozygotic twinning ;

the diagnosis of twins as monozygous or dizygous ;

the efficiency of twins as experimental material ;

heritability studies.

He concludes that, although statistical data indicate that the frequency of monozygous twinning is low, with more efficient systems of collection, sufficient twins to make large-scale investigations possible should be available. A high degree of reliability in the diagnosis of monozygosity is now attainable from the critical appraisal of certain visual characteristics and from blood typing. Uniformity trials and information from treatment experiments in which twins have been used have shown fairly conclusively the marked experimental superiority of monozygous twins over ordinary animals. However, an exaggerated confidence in their superiority may have led to some inconclusive twin experiments. Twin efficiency values are given for a large variety of characters. Twins on average, are about 15 times as efficient as unrelated animals, but range from equally to 72 times as efficient.

Several twin experiments have yielded heritability estimates for characters connected with growth and production. The apparent conclusion would be that 85-95 per cent of the variation in most of these characters is under hereditary control. The author estimates from monozygotic twins that the heritability of milk yield, for example, was 90 per cent, compared with the more generally accepted figure from herd studies of about 30 per cent. He agrees with a conclusion drawn by Swedish workers that heredity plays a very prominent role in the expression of all productive characters and usually outweighs the effects of differences in feeding intensity, even when these differences are large.

ST.C.S.T.
H.P.D.

Body Development in Relation to Heredity and Intensity of Rearing. A. HANSSON, E. BRANNING and O. CLAESSON. *Acta. Agric. Scand.*, 1953, **3**, 61-95.

The first of these papers deals with a rearing experiment employing sixteen pairs of identical heifer twins, divided into four groups. One member of each pair was fed a control ration, whilst the other received 60, 80, 120 or 140 per cent of the control ration, depending on the group to which it was allocated. As the animals grew older, the more intensive feeding levels had less and less effect on growth rate relative to the other levels; and in the final stage of the experiment, the control group was actually gaining more rapidly than those receiving 120 and 140 per cent of control feeding. On the other hand, the demands of pregnancy prevented the 60 per cent group from making gains in the final stage. The authors conclude that intensity of feeding influences growth rate most in early life; that twins, however fed, reach almost the same body development at maturity; and that those animals making greatest gains in early life exhibit a corresponding reduction in later stages. The flexibility of growth rate at any given age will therefore depend upon the level of nutrition employed earlier.

By dividing the experiment into 90-day periods, estimates were made of the relative influence of nutrition and heredity at different ages, comparing variation within pairs (nutritional) with that between pairs (heredity + nutrition). Basing conclusions on the results of this analysis, it is stated that the level of nutrition had a big effect up to 25 months of age, especially in the low-level groups. Provided an animal is growing to capacity, the rate at which it does so will be determined by genetic factors, and heredity will direct development to a pre-determined end-point. Varied nutrition can only alter the rate at which the end-point is reached.

An attempt to calculate the maintenance requirement of the growing animal was abandoned on the grounds that live weight, age, distance from maturity and genetic capacity are related in too complex a manner. The energy content of each unit of growth increases as animals get older, due to increasing fat deposition. It was not possible to account for the dropping off in growth rate on an energy basis, however. No influence of feeding intensity on digestion was demonstrated. Respiration and heart rate markedly increased at higher-feeding levels. It is concluded that on the lower levels animals made the most efficient growth.

Milk Secretion in Relation to Level of Nutrition. A. HANSSON, E. BRANNING and O. CLAESSON. *Acta. Agric. Scand.*, 1954, **4**, 85-93.

Two experiments are described. In the first, using three pairs of monozygous twins, all animals received the same maintenance ration in relationship to body weight, but for milk production one twin in each

pair received 0.35 and the other 0.45 Scandinavian feed units per kg. fat-corrected milk produced. In terms of the production ration, those twins receiving 0.35 f.u. were more efficient convertors.

In the second experiment, six pairs of twins were used in three groups of two pairs each. In these three groups the experimental twin received 80, 90 or 110 per cent of the level of nutrition of its control mate. The consumption of production feed in Scandivanian f.u., after allowing for maintenance, was respectively 0.27, 0.34, 0.39 and 0.43 per kg. fat-corrected milk for the 80, 90, 100 (control), and 110 per cent feeding levels. The two experiments show that the output of milk per unit of total feed follows the law of diminishing returns. This controverts the old idea that milk production increases in direct proportion to increased feed until the level set by the feeding standard is reached.

J.H.W.
H.P.D.

Sexual Functions of Bulls in Relation to Heredity, Rearing Intensity and Somatic Conditions. A. BANE. *Acta. Agric. Scand.*, **4**, 2.

The first requisite of a bull is fertility. This paper describes experiments with six identical twin bull pairs, designed to investigate the significance of breeding and feeding on fertility. The author concludes that great differences between twin pairs during the age period 18-36 months reflected substantial genetic influences on volume of ejaculate, sperm concentration, total number of sperm, duration of motility, and frequency of abnormal sperm heads and cytoplasmic drops. There was no significant linear regression between the level of nutrition and any sperm characteristic up to the age of 18 months. Inherent constitution had a dominant influence on the bulls' mating behaviour but this also was not affected by the level of nutrition during rearing.

G.B.Y.
H.P.D.

Genetic Analysis of the Red Danish Breed of Cattle. A. ROBERTSON and I. L. MASON. *Acta. Agric. Scand.*, 1954, **4**, 2.

The majority of cattle in Denmark are of the Red Danish breed which originated a century ago from inter-breeding local cattle and imported bulls. At first, improvement was effected largely by breeding bulls from the best cows, then progeny testing came to the fore and owing to its use the breed has become concentrated into blood lines with nearly all present-day sires tracing back to two born thirty years ago.

A genetic analysis was made by a method of pedigree sampling involving double lines. Two groups of fifty animals were chosen, the bulls being selected from sixty-one sires having daughters tested between 1949 and 1951, and the females chosen at random from the cow herdbook, entry to which is based on individual merit. The authors show how the genetic contribution of an individual ancestor to the two samples is calculated and give examples of the influence of particular sires. The mean coefficient of inbreeding can be estimated from the number of common ancestors counted in a pedigree. Inbreeding in cows was found to be 4.7 per cent, and that for bulls 11.2 per cent, this being due largely to the use of two popular sires. One was a carrier for hindquarter paralysis at birth, and was responsible initially for the spread of this undesirable gene through the breed, and its consequent rise in frequency. The level of inbreeding in the chief herds supplying A.I. bulls is high, being about four times the average for most breeds. In commercial herds the level has increased due to A.I., and may be raised further if the use of frozen semen becomes general. Inbreeding in dairy cattle leads to depression of yield, but the relation between them is not clear.

An expression relating sire superiority to inbreeding depression is discussed, the chief problem being to balance these two factors so as to secure the maximum improvement.

J.M.P.
H.P.D.

Blood Groups : Some Uses in Livestock Breeding Research

The surfaces of red blood cells possess chemical properties which vary with the individual [1]. They are called " antigens " and appear to be inherited as independent characters. In cattle, the blood typing of any individual for the presence or absence of these antigens has enabled the differentiation of one animal from another, with the exception of identical twins. When the red blood cells of one animal are injected into the blood of another, highly specific antibodies will be produced against each of the antigens which the receiving animal does not possess itself. In order to utilize these findings for genetic purposes, e.g., aiding diagnosis of identical twins or deciding disputed parentage, testing fluids (reagents) must be obtained containing antibodies for only one antigen. When the reagent is added to the blood of an animal lacking the particular antigen, the red blood cells settle to the bottom of the test tube after an hour or so, and leave a clear, *colourless*, supernatant fluid. When the blood contains the character for which the reagent is specific, a break-down (haemolysis) of the red blood cells ensues, leaving nothing but a clear *red* fluid. By developing a range of these specific reagents an animal can be blood typed.

The antigenic structure of the blood of cattle is very complex. Published results report about forty antigenic factors. A picture has been steadily built up suggesting that a group of associated antigens may be controlled by a single gene [2 and 3]. Further discoveries have led to the grouping of these related factors [3 and 4]. Each group of factors is now assumed to be controlled by a single gene, occupying a single point (locus) on one of the chromosomes which go to make up the nucleus of each cell in the animal's body. No less than twenty-one factors are determined by the B-locus in cattle [4]. Arranged in various combinations, they have so far provided eighty-nine alternatives. Each alternative is regarded as the product of a single pair of genes. Some genes determine a single factor, others determine a combination. The C-locus has seven factors with similar variations in combination. The application of these principles to a case of disputed parentage is described by Stormont and Cumley [1]. The dam of a Guernsey calf was mated to two bulls during one heat. By comparing the antigens of the calf's blood with those of her dam and of the two bulls, the following picture was built up. The calf had the characters H, O, R and S which were not present in her dam's blood and must have come from the sire. One bull possessed all these characters ; the other lacked O and R. It is also possible to study more thoroughly variations in length of pregnancy, and to determine when, during heat, a cow is most likely to conceive by using semen from different bulls during one heat and then blood-typing the offspring, its dam and each bull used.

One-egg twin pairs have identical blood types. Due to anastomosis of the blood vessels during pre-natal life, two-egg twins usually possess a mixture of red blood cells during their whole life. The proportion of the two types is the same in both animals, but not necessarily 1 : 1. One member of a pair may possess a larger proportion of its mate's type of blood cells than of its own. When two-egg twins of unlike sex have a mixture of two-blood types, it indicates that anastomosis took place, and that the female will be a freemartin. In about 10 per cent of twin pregnancies, anastomosis does not occur. The two-blood types of two-egg twins would then be distinct for each animal, and in unlike-sexed pairs the female would be fertile.

The possibility of using blood-grouping methods for detecting linkage between blood-group genes and those controlling characters of economic importance appears promising where these are inherited simply, e.g., lethal and sub-lethal defects [6]. For quantitative traits, e.g., meat, milk, egg production and conformation, results might not be so clear. Nevertheless, studies with poultry [7] indicate that individuals possessing the more complex blood type—consisting of many characters—may

show superiority as regards production over individuals with simpler combinations. The study of hybrid vigour and crossbreeding may consequently be aided by blood-typing.

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J.H.W.
H.P.D.

Crop Husbandry

Fertilizers

J. W. S. REITH has summarized recent experimental work on the behaviour of oats, wheat and barley in " Cereal Responses to Fertilizers " (*J. Scot. Agr.*, 1954, **34,** 90-4).

He points out that although oats can grow reasonably well on quite acid soils low in lime, trials carried out over the last six years on mineral soils low in lime (*p*H 5.0-5.5) show an average increase of 1.25 cwt. of grain per acre one year after bringing their lime content to a reasonably satisfactory level. His remarks apply chiefly to conditions in Scotland but they show that the results obtained there are mostly in line with English experience. He reports, for example, that there is no advantage in late dressings of nitrogen for oats ; that $1\frac{1}{2}$ cwt. superphosphates drilled produce at least as good a crop of wheat as 3 cwt. broadcast, and that on most Scottish soils the response to potash is small.

This paper ties up well with one called " The Economics of Fertilizers " (*Agric. Merchant*, 1955, **35,** 85-7) in which GRAHAM CHERRY and D. P. HOPKINS, discuss amongst other things, the rise in cropping costs of oats. Quoting figures from the Agricultural Economics Department of the North of Scotland College of Agriculture, they say that since 1945 the absolute cost of growing oats has risen by 74 per cent. The data emphasize the great need to grow full crops through the use

of fertilizers. This brief paper is of interest not only to crop and grass husbandry officers but also to the soils and fertilizer specialist, and has a direct bearing upon farm management studies. Its thesis is, in the words quoted from a report from the Economics Department of the University of Nottingham, " as yields increase, returns increase : and as variations in costs are small and irregular, the margins increase tremendously with increases in yield."

A subsidiary effect of fertilizers on cereals forms the theme of a contribution by E. N. GREER and G. C. GRINDLEY called " The Late Manuring of Winter Wheat : An Observation of the Nutritive Value of the Grain " (*J. Agric. Sci.*, 1954, **45,** 125-8). The authors fed rats upon wheat from manurial trials, the nitrogen contents of the wheat differing by reason of the fertilizer treatments applied. It was found that pairs of rats showed increased growth when fed wheat of higher nitrogen content. The authors suggest that the difference was due, not to an increase in the acceptability of the diet, but to the greater nutritive value of the grain from the manurial plots. The implication, they say, is that the feed value of a crop of winter wheat can be improved in its protein content by appropriate treatment with nitrogenous fertilizers, but that the extent of such improvement is probably limited, and it is a comparatively rare occurrence to find English-grown wheat containing more than 13 per cent of protein, even when heavily dressed with nitrogen.

Seed Dressings of Cereals

Another report dealing with cereals is J. R. THOMSON'S " The Effect of Seed Dressings Containing an Organo-Mercurial and Gamma BHC on Germination Tests of Oats " (*Emp. J. exp. Agric.*, 1954, XXII, **87,** 185-8). The author states that when mercurial/BHC seed dressings became popular, it was noticed by seed testing stations that abnormal seedlings were liable to appear—most frequently in barley and wheat, but also in oats. Characteristic symptoms were a thickened coleoptile and short, peg-like roots, similar to those known to develop from seed overdressed with an organo-mercurial dressing alone, but occurring more frequently and with the symptoms exaggerated. As a result of tests, Thomson states that the injurious effects are too slight to be of practical importance. The bad effect is almost completely confined to the groats (i.e., the naked caryopses). The number of abnormal seedlings tends to increase the longer the seed is stored after dusting, but, even after a year, the effect in good storage conditions was still of no practical importance. The number of abnormal seedlings is greater with sand than with soil as a germinating medium. The author is careful to say that his conclusions are drawn from experiments with seed well-harvested, adequately dried, and treated with the recommended dose, and are not necessarily applicable in other circumstances.

G.E.F.
D.H.R.

Dairy Husbandry

Milk Quality

Two further papers concerning the effect of low-fibre diets on the fat content of milk have been contributed by workers at Shinfield (C. C. Balch, D. A. Balch, S. Bartlett, V. W. Johnson, S. J. Rowland and Jill Turner. *J. Dairy Res.*, 1954, **21,** 305; C. C. Balch, D. A. Balch, S. Bartlett, Zena D. Hosking, V. W. Johnson, S. J. Rowland and Jill Turner. *J. Dairy Res.*, 1955, **22,** 10). When the hay ration of milking cows was reduced to 4 lb. daily and the remainder of the ration consisted of a home-mixed concentrate mixture containing 50 per cent flaked maize, a marked depression in fat yield took place. Where, however, the daily ration of 4 lb. hay was fed in conjunction with a concentrate ration consisting of purchased cattle cubes of a fairly complicated mix, no decrease in fat production was observed. Digestibility determinations showed that the differences in the effect of these two concentrate mixtures on the fat content of milk could not be attributed to differences in the digestibility of the rations *per se*. There was evidence that the effect was caused by differential function of the reticulo-rumen, due partly to the starch content of the concentrate ration containing flaked maize and partly to its physical characteristics, particularly its absence of " fibrousness ".

In a further experiment with the same low level of hay a comparison was made between three concentrate mixtures. All the mixtures contained 35 per cent weatings and 15 per cent decorticated groundnut cake, with the addition to each of respectively 50 per cent flaked maize, 50 per cent maize meal, and 50 per cent crushed dredge corn. A marked fall in fat content of the milk of the cows receiving the flaked maize, and a small (but not significant) fall in the fat content of the milk of the cows receiving the maize meal, was observed, while the concentrate containing the dredge corn had no effect on the fat level. Since the level of starch intake was very similar in all cases, it appeared that the type of starchy concentrate might have considerable effect on fat content where these low-hay/high-concentrate diets are used.

From time to time it has been suggested that seaweed meal will affect favourably the quality of milk, and Dunlop (*Fmrs' Wkly*, 1952, **37,** 59) concluded that small additions may increase butterfat production. In a recent investigation (A. W. A. Burt, S. Bartlett and S. J. Rowland. *J. Dairy Res.*, 1954, **21,** 299), however, no significant response either in yield or fat percentage was obtained by including 10 per cent of seaweed meal in the concentrate mixture in place of $8\frac{3}{4}$ per cent oatfeed plus $1\frac{1}{4}$ per cent common salt and, indeed, the milk from cows receiving oatfeed was slightly, but significantly, higher in non-fatty solids.

Hay Feeding

The proportion of hay to concentrates appears to be of importance so far as milk quality is concerned only at low levels of hay consumption —usually below 6 lb. per head daily. The ration of hay to concentrates has, however, considerable effect on milk yield over a much wider range, and is of great economic importance, since the cost of nutrients from hay in relation to the cost of those in concentrates may vary widely. In a recent investigation in Iowa (T. G. MARTIN, G. E. STODDARD and R. S. ALLEN. *J. Dairy Sci.*, 1954, **37,** 1233), comparison of bodyweight changes and milk production was made in groups of milking cows where the hay ration was limited to 0.50, 1.17, 1.83 and 2.50 lb. daily per 100 lb. of bodyweight; the remainder of the maintenance ration and the production ration being made up to Morrison's standards with a concentrate mixture. The mean milk yield of the groups of cows used was between three and four gallons and there appeared to be a small but significant decrease in yield with increasing hay ration. However, when allowance was made for food refusals and the intake of nutrients based on analyses of actual foods consumed, these varying levels of hay intake appeared to have no significant effect on yield. Thus with the hay used (30.3 per cent fibre and 11.7 per cent protein) there appeared to be a fairly wide range over which the ratio of hay to concentrates could move without significantly affecting the efficiency of the ration, as measured by ratio of calculated total digestible nutrients required to total digestibility nutrients supplied. Owing, however, to food refusals the higher levels of hay feeding tended to reduce yield.

Bloat

Although bloat occurs spasmodically on farms in many parts of the world, no satisfactory explanation of its precise cause has yet been found. In New Zealand the disorder is particularly troublesome, partly owing to the abundance of clover in some of the grazing swards. JOHNS (*N.Z.J. Sci. Tech.*, 1954, **36,** 289) has recently reported results of investigations in that country. Johns found that he could induce bloat in dry dairy cows by feeding them on cut Broad Red Clover (*Trifolium pratense*) in stalls at 8.30 a.m. and 1.30 p.m., following a fasting interval during the previous afternoon, evening and night. In this way he was able to test the influence of various factors commonly quoted as causing or contributing to the condition—such as weather conditions, stage of growth of the clover, the dry-matter content of the clover, effect of supplementary feeding, influence of rate of feeding, etc.

In the five animals used, Johns induced 429 cases of bloat and these formed the basis for testing the various theories as to the cause of the disorder. In general there was little evidence to support the suggestion that lack of roughage, presence of a toxic principle, or an allergic condition were involved in these cases, and eructation often continued while the animals were becoming bloated. There was, however, good evidence that the bloat concerned was the frothy type, in which gas is produced

by microbial fermentation in the rumen contents more quickly than it is released as free gas at the top of the rumen. Anti-foaming agents such as silicones, peanut oil, olive oil, soya-bean oil and turpentine " never failed to protect animals from bloat or failed to relieve bloated animals ". Johns thought that the foam system involved would not be simple, since at least three factors might be involved—saliva, saponins from the legumes, and proteins and their breakdown products.

It must not be assumed that the bloat produced in the New Zealand experiments was necessarily of the same type as those produced in other countries or under other conditions. LINDAHL, COOK, DAVIS and MACLAY (*Science*, 1954, **119**, 157) in the United States were able to produce bloat in sheep, a goat and a heifer, with saponin from lucerne. In these cases, however, the distention appeared to be due to free gas rather than froth, and the condition could be relieved by stomach tube.

Milk Secretion

Further studies of the phenomena involved in the secretion of milk and fat into the udder and their " ejection " and removal from the udder have been reported. BAILEY, CLOUGH and DODD (*J. Dairy Res.*, 1955, **22**, 22) attempted to measure the actual rate of secretion of milk and fat into the udder by milking cows at intervals of 3, 6, 9, 12, 15 and 18 hours. Their investigation was carried out in two parts. In the first the intervals between milkings were arranged so that each interval followed itself and also every other interval. In the second, each interval was applied for several consecutive milkings, so that as each regime became stabilized, the milk and fat obtained at a milking would be equivalent to the secretion into the udder over the previous interval. A statistical analysis of the results showed that yield of milk and fat was influenced, not only by the length of the interval immediately preceding the milking, but also by the intervals previous to that. The rate of secretion of milk and fat decreased with length-of-milking interval but the decline for milk was apparently slightly greater than that for fat, and as a result the fat percentage tended to increase with length of interval. The data also showed that fat yield at a milking was influenced to a greater extent than milk yield, by the length of intervals further back than the interval immediately preceding the milking. The study provided evidence that the interval between milkings may affect milk and fat production, not only on account of differences in the carry-over of residual milk, but also because the length of one interval may apparently affect the " metabolic rate " of the alveoli in the next interval.

In Minnesota, DONKER, KOSLII and PETERSEN (*J. Dairy Sci.*, 1954, **37**, 1261) studied the rate of milk and fat secretion where cows were milked for long periods at hourly intervals and at intervals of up to 16 hours ; in all cases the milkings were carried out following intravenous injections of oxytocin. Where hourly milking was carried out for periods up to 156 hours the milk yield was first high owing to residual milk, then settled back to a pre-experimental rate of hourly secretion,

and then tended to rise to about 120 per cent of the pre-experimental rate. Fat secretion followed the same trends in a more exaggerated form and the experimental treatment resulted in an initial rise to over 8 per cent fat, followed by a decline to below 3 per cent and a gradual increase to about 6 per cent compared with a mean pre-experimental level of a little over 4 per cent. The increased fat secretion resulting from the experimental milkings cannot be explained on the basis of present knowledge of udder function.

Many efforts have been made in recent years to achieve normal lactation by hormonal induction and without pregnancy. In New Zealand, HANCOCK, BRUMBY and TURNER (*N.Z.J. Sci. Tech.*, 1954, **36,** 111) compared the yield of one-egg twins where one member of each set calved following a normal pregnancy, and the other member was not put in-calf but the udder growth was stimulated with oestrogen and progesterone and lactation initiated by increasing the oestrogen injections during the final 30 days of treatment. In four sets of twins in which the control member gave normal yields, the members in whom lactation was induced gave from 42-72 per cent of their respective control mate's yield.

Milk Fever

In the past, the use of vitamin D for cows during late pregnancy and immediately after calving to prevent milk fever has usually not been very successful. It has been suggested that this may be due to the suppression of parathyroid activity when vitamin D is given over long periods at moderate levels, while high levels over such periods might adversely affect the general health of the animal. HIBBS and POUNDEN (*J. Dairy Sci.*, 1955, **38,** 65) attempted to overcome these difficulties by feeding high levels of vitamin D over periods not exceeding seven days pre-partum and one day post-partum. Of 31 cows so treated, 14 were given either 20 or 30 million I.U. per day and no case of milk fever was observed, while 19 received either 5 or 10 million I.U. and two cases of milk fever were observed. Comparable cows receiving no vitamin D showed an incidence of milk fever of over 50 per cent. While the minimum effective dose of vitamin D was not ascertained, it was considered that the administration of vitamin D for a short period at the end of pregnancy offered an effective method of preventing milk fever.

A.S.F.

Entomology

The Host Plant Range and Economic Importance of a Group of Gall Midges *(Thomasiniana* spp.*)* Associated with Fruit. R. S. PITCHER. *Ann. Rept. East Malling Res. Sta.*, 1953, 168-70.

A comparison is made of all the members of the genus *Thomasiniana* known to occur on rosaceous plants. These include the Hawthorn Stem midge, the Raspberry Cane midge and a new species on wild

blackberry. The Red Bud Borer (*T. oculiperda*) has been shown to contain biologic strains from either apple or roses, though both types can live to some extent on either host and cause injury to budded rootstocks of each. Large colonies of both strains have been found living in broken branches of established apples and of wild roses in hedgerows. Since it is probable that such sites form reservoirs of infestation, it is suggested that nurseries should, where possible, be sited as far away as possible from established apple orchards, and that roses in hedges should be kept down.

Spray Application Problems XI. A Note on the Preparation of a Combined DDT-*Gamma* BHC Emulsion of High-Wetting Properties as a Substitute for Winter Washes. H. G. H. Kearns and N. G. Morgan. *Ann. Rept. Agric. and Hortic. Res. Stat., Long Ashton, Bristol*, 1953, 146-8.

The use of DDT and BHC as substitutes for winter washes on fruit crops, though established, has given rather variable results in practice. This is due to the use of formulations of insufficiently high-wetting properties, often in conjunction with inefficient spraying. Moreover, the high concentrations of DDT and BHC usually recommended may lead to high residual deposits on the tree, thus increasing the duration of toxicity to beneficial insect predators and so aggravating the Red spider situation.

The importance of correct timing of the applications for various pests is dealt with. The control of aphids by DDT must be well timed and the emulsion must be of highly-efficient wetting power. The wash should be applied so as to coincide with bud burst of the variety Worcester Pearmain. If not applied then, the spraying should be delayed until the advanced green bud stage, when the aphids are again exposed on the flower stalks which have separated. Apple sucker is not so easily controlled as aphids since it enters tightly clustered buds. Bud burst may often be too early for caterpillar control. Good results may, however, be obtained at any stage from bud burst to pink bud. With good timing and well-compounded emulsions of good wetting power, DDT need never exceed 0.025 per cent ($\frac{1}{4}$ lb. per 100 gal. of diluted wash).

BHC wettable powders and emulsions giving control of aphids and sucker need less critical timing, but are not so effective against caterpillars and capsid as DDT. An emulsion containing 0.007 per cent *gamma* BHC ($1\frac{1}{8}$ oz. per 100 gal. diluted wash) gave complete control of aphids.

The preparations of a combined emulsion of DDT and BHC is described, embodying di-octyl sodium sulphosuccinate as a wetter. The stock emulsion is used at the rate of 1 pint per 100 gal. of water together with 4 oz. of the wetter. No doubt this formulation will in due course be available on the market as it could not easily be made by a grower.

Carrot Fly and "Canker" of Parsnips in the South-West. L. E. W. Stone. *Plant Path.*, **3,** 118-21.

The purpose of this work has been mainly to investigate any possible relation between Carrot fly injury and "Canker", and the experiments have been carried out from 1949 to 1953. Various treatments were carried out, such as dusting with BHC, spraying with DDT and seed treatments with BHC preparations. From the various experiments, information was obtained concerning the degree of attack by Carrot fly by the examination of individual roots. The categories for Carrot fly attack were "Absent", "Slight", "Moderate" and "Severe". Canker was assessed in a similar manner. The dependence of Canker upon Carrot fly injury was obvious. In no case was Canker found to be present in the absence of Carrot fly mines and this experience held throughout the trials.

The form of Canker encountered in the trials was clearly initiated by Carrot fly attack, and its subsequent development appeared to be influenced by many factors, particularly summer rainfall.

The Use of Seed Dressings containing *gamma*-BHC in the Establishment of Sugar Beet Seedlings. F. G. W. Jones and K. P. Humphries. *Ann. appl. Biol.* 41, 562-77.

The main object of this work was to determine the effect of BHC seed dressings, with and without the addition of organo-mercurial compounds, upon the establishment of beet seedlings. Only in a few cases were the trials made in fields where serious pest problems were present, but a variety of soil types were included.

It was found that the phytotoxicity of *gamma*-BHC varied with season and soil type, but that a dressing containing 40 per cent was usually safe. Where no pests were present, the benefit of the seed dressing was usually only slight. If improvement was found, it was generally due to the inclusion of an organo-mercurial compound. Where pests were present the BHC brought about marked improvements in stand. Wireworms were well controlled but control was only partial with Pygmy Mangold beetle.

Provisional Lists of Host Plants of Some Root Eelworms (*Heterodera* spp.). R. D. Winslow. *Ann. appl. Biol.*, 41, 591-605.

Extensive host-range tests have been carried out at Cambridge during 1951-53. Comprehensive lists are given for the host ranges of Beet eelworm, Cabbage Root eelworm, *Galeopsis* (Hemp-nettle) and Clover Root eelworm, Potato Root eelworm, and Pea Root eelworm. Other eelworm on which similar work has been done are the Carrot Root eelworm and the Hop eelworm. Oat Root eelworm is another very important species.

Such a paper forms a most valuable reference in the planning of rotations for land infested with any of these important root eelworms.

Wind Direction and the Infestation of Bean Fields by *Aphis fabae*, scop. C. E. Taylor and C. G. Johnson. *Ann. appl. Biol.*, 41, 107-16.

Observations were made in bean fields at Sutton Bonnington in 1950-52 and in a field at Rothamsted in 1948. It was found that fields were often attacked very heavily along the edges, particularly on the sides facing the wind during the time of the primary migration. This was due to a heavier deposition of primary migrants. There are some interesting photographs of the fields taken from the air and it will be seen how well the areas of infestation show up in such photographs.

Hot-Water Treatment of Shallots Against Attack by the Stem and Bulb Eelworm (*Ditylenchus dipsaci* (Kuhn) Filipjev.). F. Bruinsma and J. W. Seinhorst. *Overdruk uit : Mededelingen Directeur van de Tuinbouw*, 1954, **17**, 437-46.

It has been shown that hot-water treatment of shallots gives a very efficient control of Stem eelworms. Treatment found to be effective were 2 hours at 43.5°C. or 44°C ; 90 minutes at 45°C. ; 60 minutes at 46°C.

None of these treatments caused damage or decrease in yield ; in fact there was some evidence of an increased yield resulting. Treatments were satisfactory in both autumn and spring, but the former was preferable since it prevented losses during storage.

Problems Arising from the Use of Insecticides : Effect on the Balance of Animal Populations. *Rept. Sixth Commonwealth Ento. Conf.* London, July 1954, 53-7.

This very interesting paper should be read by all those concerned with fruit culture. The author gives examples of the fluctuations of animal populations in fruit orchards, with special reference to the effects of chemicals upon the fruit-tree Red Spider, the apple Capsid bug, the Red spider mite and the Woolly aphid.

The author also stresses the risk of introducing new chemicals into spray programmes without their being tested over an adequate period ; he notes that to-day their introduction continues unabated. The situation is aggravated by the increasing use of low- and medium-volume applications, and it may take many years before the overall effects of these highly-concentrated chemicals can be assessed in the field. Spray programmes in future should not be of an arbitrary nature, but should be developed upon a sound and wide knowledge of their biological interactions. Insecticides of the future need to be more selective, rather than mere highly toxic, and spray chemists will need to work in complete collaboration with entomologists.

L.N.S.

Commonwealth Agricultural Bureaux Publications

BUREAU OF ANIMAL NUTRITION

Nutrition Abstracts and Reviews, Volume 24

Abstract 3860 deals with the debated questions of the effect of the rate at which calves are given roughage on the development of the rumen, and the supposed effect of deliberate inoculation of the calf with cud from an adult or the development of the rumen flora.

Abstract 5327 discusses the use of concentrate mixtures bought ready for use. It also announces that a molecular distillate of vitamin A has been put on the market by a Norwegian firm, so that the vitamin may be given without any danger of the production of white muscle in calves, which might happen when cod liver oil is used.

Abstract 5337. The United States National Research Council urges caution in the use of hormones to increase production.

Abstract 5404 describes a study designed to compare milk yield and butterfat production of heifers normally served or artificially inseminated.

Abstracts 5461 (N. Ireland) and *5462* (Macdonald College, Montreal) report that the efficiency of the production of pigs on restricted feed is the same as that of pigs fed to appetite. This is in terms of feed required per unit of weight gained, and may be misleading since the composition of the carcasses will not be the same. The restricted pigs will have less fat, and so in terms of S.E. or calories, the efficiencies may not be the same.

BUREAU OF PASTURES AND FIELD CROPS

Methods of Surveying and Measuring Vegetation

D. Brown, 1954, 240 pp., quarto, cloth bound; illustrated with half-tones, line drawings and tables; index, glossary and bibliography: 35s.

Parts I and II of this book were reviewed in the autumn and winter issues of this Review.

Agronomists and progressive farmers will be interested in the chapters on the productivity of grazing land and carrying capacity in Part III of this work. Methods are described for evaluating the amount of herbage produced under a wide range of climatic conditions. Of special interest at the present time is the chapter on pasture recording.

Provincial Note

Poultry and Grassland

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BETWEEN 1950 AND 1954 the average poultry population of Devon and Cornwall was slightly over five million birds, which gives an indication of the importance of poultry husbandry in these counties. Furthermore, the farms in the area are mainly small, with grassland predominant and the most important crop.

Bearing these facts in mind, observation studies dealing with *Folded Poultry on Maiden Seeds* and *Suitable Seeds Mixtures for Fixed Poultry-Pens* were carried out in Devon and Cornwall between 1949 and 1954. Despite the ever-growing trend towards intensive methods in the poultry field, the results of these studies, which are summarized in this article, may not be without interest to those farmers and breeders who still recognize the use of poultry in the improvement of grassland, and realize the advantages which a "natural system" may have in maintaining health and constitutional vigour, especially where breeding stock is concerned.

Effect of Folding Poultry over a Ley in the Year of Seeding

With the co-operation of the Devon School of Agriculture, Bicton, East Budleigh, detailed observations were carried out during three consecutive years from 1949. The object was to gain information on :

The effect of folded poultry on a ley in its early stages of growth;

The optimum time that poultry in fold units can be introduced on to maiden seeds without causing damage;

The effect folded poultry may have on the establishment of the ley in association with the grazing of other farm animals.

Three adjacent sites on sandy loam were used. The land was previously parkland, the original herbage being poor and infested with bracken. The grasses consisted mainly of red fescue, bent and a few other species—virtually no clover was present. Each site, in turn, was

ploughed up in the winter, cultivated, limed and manured in the spring, and sown in May to the following seeds mixture :

	lb. per acre
New Zealand Italian ryegrass	3
New Zealand Mother perennial ryegrass	12
S.143 cocksfoot	8
New Zealand Mother white clover	2
	25

Every year 1 ton per acre of ground limestone was applied and about 4 cwt. of superphosphate, 2 cwt. muriate of potash and 1-2 cwt. of " Nitro-Chalk " to the acre were worked into the seed bed. In the first year, 1949, the seeds were sown broadcast, in the second year they were drilled (one way only) and in 1951 they were drilled both ways. On the light land concerned it was considered that a better " take " was obtained by drilling, though it was realized that the weather conditions and tilths obtained in the different years also affected this.

Poultry were put out on the reseeded areas six to eight weeks after sowing. Generally this coincided with the first light grazing with cattle. Fold units measuring 11 ft. 6 in. $\times$ 5 ft. were used and they were stocked at the rate of 15 Rhode Island Red hens per unit giving $3\frac{3}{4}$ sq. ft. per bird. Later the birds in each fold were mated with one Rhode Island Red male. Feeding consisted of a wet mash in the morning and grain in the afternoon. The folds were moved daily in a lengthwise direction.

RESULTS

From the regular observations made on the sites, the main points of note were :

A tendency for the young sward to be damaged in the early stages due to scratching by the birds. The extent to which such damage occurred, however, seemed to depend, in these studies, on the weather and other conditions. The damage was more extensive in the first year, when the seeds were sown broadcast and weather conditions were dry, than in the two following years, when the seeds were drilled and the seasons were wetter.

The suppression of the clovers in the early stages. This tendency was considered to be due to the facts that the poultry consumed the clover readily and the growth of the grasses in the mixture was stimulated by the folding, thereby shading the young clover plants. By the end of the maiden seeds' year, however, the clovers had established satisfactorily in every case.

The need for controlled grazing by cattle or sheep in association with folding. This was apparent during each year of the experiment, and where the folds were moved on to grass allowed to grow more than 3-4 in. high there was a danger of the birds trampling it down, with subsequent rotting of the plants and a patchy sward.

CONCLUSIONS

From the experiences gained in observing these studies over a three-year period it is felt that poultry in folding units can be introduced on to maiden seeds with reasonable safety three months after sowing, provided that :

(*a*) Fold units are moved *daily*.

(*b*) Grass growth outside the folds is controlled by grazing with other stock. The consolidation provided by this also helps in the establishment of the sward.

It should be noted, however, that these results apply to only one set of conditions.

Suitable Seeds Mixtures for Fixed Poultry-Pens

Between 1949 and 1953 several observation studies were laid down with the object of obtaining information on the suitability of a large number of species of grass and a few clovers for sowing in mixtures for fixed poultry-pens in Cornwall. Three sites were selected, though all centres did not have the complete series of mixtures, and at each centre different mixtures were sown in different years as pieces of land became available.

In all, twelve mixtures were sown which varied greatly in composition and seed rate. However, they fall into three main categories :

(*a*) *Ryegrass dominant mixtures.* In these, perennial ryegrass was sown at from 6-12 lb. per acre, sometimes only with clovers and in other cases with other grasses and clovers.

(*b*) *Simple non-ryegrass mixtures.* These consisted of one grass only with white clover. The grasses were selected with the intention of providing a fine, dense, durable sward which would not produce too much growth. The species tried were S.50 timothy, S.59 red fescue, New Zealand Brown Top, rough-stalked meadow grass and Bell's smooth-stalked meadow grass.

(*c*) *Complex non-ryegrass mixtures.* These consisted of mixtures of the species used in the (*b*) types with white clover.

All the mixtures were broadcast direct, without cover crops, and adequate fertilizers were applied at sowing time.

RESULTS

It is unfortunate that on certain plots in some of the centres it was difficult to select land which was really suitable. Also it proved extremely difficult to carry out cultural operations at the optimum times owing to the lack of suitable machinery and equipment on specialist poultry-holdings. Furthermore, in some cases it was impossible to avoid sowing the mixtures as direct reseeds from poor permanent pasture, without the pioneer cropping which would have improved the fertility and given opportunities to kill weeds. With the slower-establishing mixtures of the (*b*) and (*c*) types this was particularly detrimental.

Another factor which operated against the successful establishment of some mixtures was that they were sown far too late in the autumn—even for Cornish conditions.

Results from observation studies of this type are very difficult to assess. Nevertheless regular and detailed observations were made on all sites and the following is an attempt to summarize these :

1. Under Cornish conditions, perennial ryegrass appeared too aggressive and productive for poultry swards. It rapidly became dominant wherever it was sown. Where, however, a prostrate strain was used (e.g., S.23), the surplus growth controlled and a good clover-content maintained, very useful poultry swards resulted.
2. It has proved very difficult to assess the suitability of the non-ryegrass mixtures (*b*) and (*c*) because, as has been explained, many were sown under unsatisfactory conditions. In any case, such species would be difficult to establish on any specialist holding that did not carry, or could not obtain, sheep or cattle, or both, to graze them during the period of establishment. Where the species were established satisfactorily, especially the complex non-ryegrass mixtures at one centre where sheep grazed them throughout the seeding year, a favourable short growth with fewer seed heads resulted. The sward was hard wearing and should be long-lived.
3. It has been particularly noticeable at all the sites that every mixture will grow away from the poultry at certain times during the season. This is, of course, not so marked with the non-ryegrass mixtures, but it still occurs. *Some means of controlling this surplus growth is essential.* At one centre sheep were used satisfactorily for this purpose and themselves made a profit. At another centre a mechanical scythe was used and the plots were always kept in perfect condition.

CONCLUSIONS

It appears that the first essential is to have some means of controlling all grass that grows away from the poultry. Where such means are available the actual mixture used is of secondary importance, although less frequent cutting or grazing is generally necessary where non-ryegrass mixtures are used. Where ground to be sown is clean, in good heart, and cattle or sheep are available for grazing, it is probable that a mixture of the non-aggressive species (e.g., mixtures of the (*c*) type) would be most suitable. If the ground is dirty or establishment is likely to be difficult, or both, the quicker-establishing grasses would probably be most successful. Care should be taken, however, to select a prostrate strain of ryegrass such as S.23.

Our sincere thanks are due to the farmers and the Devon School of Agriculture who so kindly co-operated with us in this work, and to our colleagues in Devon and Cornwall for their help.

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